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THE RELATIONS BETWEEN ETHER AND MATTER.

Æther and Matter. By Joseph Larmor. Pp. xxviii + 365. (Cambridge University Press, 1900.)

THIS work is essentially the same as an essay to which an Adams Prize was awarded by the University of Cambridge. The subject for which the prize was offered was Aberration, and as this phenomenon, together with the Doppler effect on the frequency of light vibrations are the only ones known due to the motion of matter through the ether (the spelling æther is disagreeably cumbrous), it naturally led to a discussion of the connection between ether and matter, and the effect of their relative motion on the phenomena of electro-magnetism.

There is a good deal of similarity between the development of this work and that of Maxwell's treatise. If one reads Maxwell's papers, it is pretty evident that he began with a somewhat definite hypothesis as to the nature of the strains in the ether to which he attributed electro-magnetic phenomena; but in his treatise on electricity and magnetism there is hardly a trace of all this except in the reference to molecular vortices by which he justifies his equations for wave-propagation in magnetised media. In a similar way, Mr. Larmor has published papers in which the relations between ether and matter are developed in connection with a suggestion as to the nature of an electron which is only hinted at in the body of the present work, and is relegated to an appendix with some deprecatory remarks as to its being merely an analogy to show that the properties of an electron are not impossible. The hypothetical structure attributed to an electron requires the medium to possess a very remarkable property which we do not find in matter, namely, an elastic reaction against absolute rotation of its elements; and although Mr. Larmor shows that gyrostats connected with these elements might confer such a property on them, he does not go so far as to develop any very definite structure for the medium, contenting himself with having shown that such properties as he assumes are not necessarily anti-dynamical. No structure for the medium that depends on gyrostats supported by a rigid framework can possibly be more than a rough working hypothesis, being, in fact, very little better than the brass wheel and india-rubber band, or tubes full of liquid with circulating pumps, that have been suggested as models to show that Maxwell's equations do not necessarily postulate impossible or adynamical properties for the ether.

But just as Maxwell's treatise is really independent of the dynamical analogies from which it grew, so Mr. Larmor's work is really independent of his suggested working analogy as to the structure of an electron. The whole work is based upon the hypothesis that electricity is atomic in its nature, there being only two kinds of atoms, positive and negative electrons. These electrons are, he supposes, essentially centres of strain in the ether, and move from place to place in much the same way as a drop of water might move through ice, melting in front and freezing up behind. Mr. Larmor leaves it for future investigation to determine whether there is any core, like that of a vortex ring, that accompanies this complex strain wave as it moves through the ether. As to the nature of matter, the only suggestion is that it consists of clusters of electrons in orbital motion round one another; but as the dynamics of such a system has never been worked out, it is impossible either to assert or deny the possibility of a permanent existence of such clusters. If this be the structure of matter, it certainly makes it probable that the transmutation of the elements is a possible development of chemistry, while a structure such as that of knotted vortices would make it improbable that we would ever be able to untie them and thus transmute one atom into another. There is the alternative possibility that we may find means of transmuting elements within any one of their related groups, but that we may find ourselves unable ever to transmute one group into another. Of course, if we ever found out some means of manufacturing electrons and matter we could probably transmute one kind of matter into another, though this latter might be possible according to Mr. Larmor's hypothesis, while the manufacture of either electrons or matter would be impossible.

All theories that explain electric currents by the motion of electrons are really based upon Rowland's classical experiment, that a moving electric charge produces the same magnetic effects as an electric current, and its converse that the electric force due to changing magnetic induction produces the same effect in moving an electric charge that the electric force due to another electric charge would produce, *i.e.* that electric force due to these two causes is the same. Our whole treatment of electro-magnetism is practically based upon these same assumptions, but it is remarkable that so few attempts have been made to repeat this fundamental experiment of Rowland's, and no successful attempt seems to have been made to directly verify its converse. In a recent number of the *Comptes rendus* there is an account of a most interesting attempt to measure the electric current that one would expect to be produced in a surrounding coil when a convection current such as Rowland studied is being started and stopped. M. Cremieu has carried out an experiment on this with great care, and in a form in which one would certainly expect that the changing magnetic induction due to the magnetic force Rowland observed should produce an induced current in a coil of wire. He observed no such effect, and concludes that there is no magnetic force such as Rowland observed due to a moving electric charge. These moving electric charges are, however, in some respects, so imperfectly known that there may yet be some difference between driving a current by mechanical and electrical forces, and that it is still possible there may be some other explanation than that drawn by M. Cremieu as the result of his interesting and important experiment. Mr. Larmor's investigations in this treatise of the effects of moving matter hardly touch the question raised by M. Cremieu, for his investigation is concerned with steady states, while M. Cremieu's experiment is essentially concerned with variable ones. If he is right and there is really no magnetic force due to a moving electric

charge, and if consequently we must look to some other, possibly accidental, cause for Rowland's observation, it will certainly revolutionise the whole modern treatment of electro-magnetism. The question raised by this experiment is, any way, one of the most fundamental ones in the connection between ether and matter, and it is to be hoped that this question will be settled soon in a conclusive way, either by showing that M. Cremieu's conclusion is not justified by his observation that his experiment really confirms a complete theory, or by overthrowing all our existing views, and leaving a free field for the twentieth century to build a new theory of electro-magnetism on a firmer foundation.

In discussing the result of Michelson and Morley's experiments, from which they concluded that the ether is carried along by the earth in its motion, Mr. Larmor shows that such a hypothesis is quite inconsistent with the fact of aberration and with the untenability of Sir George Stokes's suggestion that ether is like a very soft jelly. How such a soft material could be the means by which tramcars are driven by shearing stresses seems an additional difficulty in the way of this suggestion. Mr. Larmor concludes that the stone support on which the mirrors were borne changed in its dimensions, as it was rotated, by an amount proportional to the square of the ratio of its velocity to the velocity of light, and he justifies this by showing that if matter consists of clusters of electrons, just such a change of dimensions would take place as the experiment shows to take place. There is some difficulty in the hypothesis that the inertia of matter, or any large part of it, is like that of electrons and due to the motion of the neighbouring ether, because this involves the supposition that the inertia would change with the distance between the component electrons. That there may be some very minute effect of this kind is quite possible, though as yet undiscovered, but that any large effect of the kind exists seems extremely improbable. Possibly a careful study of the accuracy of Kepler's laws as applied to the solar system might show some discrepancy depending on a difference between the average distance of the electrons in such different materials as probably constitute Neptune and Mercury.

A previous question to all our explanations of phenomena by analytical dynamics is raised by Mr. Larmor in Appendix B, "On the Scope of Mechanical Explanation: and on the Idea of Force." He has utilised the principle of least action throughout his work, and this appendix is a justification of his doing so, and besides raises questions as to the applicability of dynamical explanation to the growth and decay of vital organisms. Hertz objected to the adequacy of the principle of least action as a complete solution of all possible dynamical systems, because it is not generally applicable when rolling takes place, and we cannot be sure that rolling may not be one of the fundamental facts of the dynamics of the ether. Mr. Larmor dismisses this objection on the doubtful ground that "rolling is foreign to molecular dynamics." Hertz had also objected to the principle of least action for the semi-metaphysical reason that it makes the present state of the system depend on the future as well as on the past. As Mr. Larmor himself uses in his work the vector potential which makes the state at each place depend on what is simultaneously occurring at all parts of the universe, he naturally finds no objection to the principle of least action, because it makes the present depend on all future time. Neither of these methods is unobjectionable; each is an analytical juggle, which has to be most carefully guarded lest it lead us into mistakes. The way in which the vector potential apparently locates the energy in the current instead of in the magnetic field outside it is a most serious objection to its use, although Mr. Larmor seems to have steered clear of the difficulties raised by this curious complication. In a similar way the principle of least action is open to the objection of Hertz of making the present apparently depend on the future to an extent that does not apply to his own principle of the straightest path. It is a question for consideration in connection with Mr. Larmor's discussion on the applicability of dynamics to vital phenomena whether the possibility of determining our actions by considerations as to the future is not connected with the possibility of analytically expressing the dynamics of the present by a formula which involves the future.

It will, from this meagre review, be evident that Mr. Larmor's treatise raises most fundamental and interesting questions, and is one that all who desire to strengthen the foundations of our knowledge of nature should carefully study. GEO. FRAS. FITZGERALD.

LAND RECLAMATION.

The Reclamation of Land from Tidal Waters. By Alexander Beazeley, M.Instit.C.E. Pp. xii + 314. (London: Crosby Lockwood and Son, 1900)

THE area of this country is gradually diminishing by the continual waste that is going on all round the coast. On the Yorkshire coast it is estimated that two miles have disappeared since the Roman occupation; and more modern records show that towns and villages have disappeared with their houses and churches, and in some cases the whole parish has been washed away. Along the Norfolk coast the only record of several villages is, "washed away by the sea"; and on the Kentish coast, churches and houses have fallen down the cliffs, on which are to be seen the bones formerly deposited in a vanishing churchyard. On the south coast, although the chalk cliffs at the east end of the English Channel are subject to continual falls and slips, more care has been taken to protect them; but along the clay cliffs of Dorsetshire the waste is continuous; here twenty acres slipped down seaward in one night from the cliffs at Axminster. On the west coast, the nets of the fishermen are said to become occasionally entangled with the ruins of houses and buildings buried in the sea some distance from the coast off Blackpool.

As some compensation for all this loss due to the ever-continuous operations of nature, the energy of man has succeeded in reclaiming and recovering a large area of rich cultivatable land in estuaries where rivers have discharged great quantities of detritus picked up along their course. At no time in the history of this country were reclamations carried on to a greater extent than in the time of the Romans, and this is the more remarkable as, compared with the population at that time, land must have been plentiful. It was during